

# Aerobic Exercise as a Warm-Up for Singing: Aerodynamic Changes

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**Summary: Objectives.** This study was designed to determine the impact of aerobic exercise on vocal warm-up.

**Study design.** This is a cohort experimental study.

**Methods.** Sixteen graduate and six undergraduate students in an academic vocal performance program participated. They completed a 30-minute treadmill workout in their target aerobic heart range. Aerodynamic data during singing were acquired before and after the treadmill workout. In full voice, participants sang the first seven notes of the Star Spangled Banner on “pah,” repeating the seventh note seven times, at 1.5 syllables/s after an inhalation. The key was determined by voice type, with the target note within the range of *passaggio* for men, and in head voice for women.

**Results.** Paired *t* tests were performed on the data from 17 singers who maintained or increased sound pressure level (SPL) after exercise. Significant pre- to post-exercise increases were found for mean SPL and mean airflow during voicing, although increased estimated subglottal pressure approached significance. These measures were essentially unchanged in individuals who decreased SPL after exercise. There was no significant difference in vocal efficiency after the aerobic exercise, primarily due to large standard deviations within the pre- and post-exercise conditions.

**Conclusions.** Most participants demonstrated favorable aerodynamic changes during singing after aerobic exercise. It is possible that in certain situations, a general aerobic warm-up could set the stage for a less-demanding vocal-specific warm-up, especially for a high voice performing early in the morning.

**Key Words:** Vocal–Voice–Vocal efficiency–Airflow–Subglottal pressure.

## INTRODUCTION

Classical singing is a complex and demanding act, yet must give the audience an impression of effortlessness. Although years of training are required to develop a healthy and efficient vocal technique, the preparation immediately before performance is equally important for optimal vocal production. Although performers differ markedly in how they use the time before taking the stage, preparation typically includes some version of a vocal warm-up.

Although virtually all performers and voice teachers agree that vocal warm-up is essential before performing, there is little consensus regarding either method or purported impact of the exercise. Some have speculated that singing warm-ups may function to improve physiology, prepare the singer psychologically, or simply act as a placebo. Barr<sup>1</sup> suggested that the physiological benefits of a warm-up may be crucial to less-trained voices, with the psychological benefits being greater for more accomplished performers. He argued that there may be a placebo effect when the warm-up has no physiological basis, but the singer nonetheless benefits, perhaps by feeling mentally ready to perform. Self-perceptions of warm-up may be deceiving, however. In one study, virtually all singers reported improvement in qualities such as “resonant voice sensations,”

with listeners noting significant change in some specific qualities, but not in the overall rating of “legit vocal quality.”<sup>2</sup> Contributing to the challenge of interpreting the benefit of warm-up is the considerable variability in warm-up methods, highlighted in a survey of nearly 120 singers at different levels of training.<sup>3</sup> Only 53% of the participants reported always warming up before singing, although another 34% stated they usually did. It was noted that singers were more likely to warm up before singing solo than in an ensemble. The duration of the average warm-up was quite brief, typically 5–10 minutes. Most of the reported exercises would be considered part of a traditional vocal warm-up, focusing primarily on vocalizations, although 21% reported using general aerobic exercise as part of their warm-up regimen.

The benefits of a traditional vocal warm-up have been documented in two studies<sup>2,4</sup> focusing on acoustic changes. After a 25-minute warm-up, Moorcroft and Kenny<sup>2</sup> found greater regularity and stability in vibrato. The most interesting finding, however, was the moderating of excessively fast and excessively slow mean vibrato rates. The authors speculated that warm-up may have a normalizing effect, increasing activation levels in some, while decreasing excess activation in others. In the second study of a traditional warm-up,<sup>4</sup> participants spent an average of about 10 minutes performing relaxation, postural alignment, breathing exercises, and voice production at varying pitches and dynamic levels. The authors found post-warm-up improvement in measures of frequency and amplitude perturbation, as well as the noise-to-harmonics ratio. They argued against a purely vocal warm-up and concluded that the inclusion of more general exercises targeting breathing, posture, and relaxation contributed to the positive changes. The findings must be interpreted with caution, however, given the nonsystematic impact of vibrato on acoustic measures.<sup>5</sup>

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As an alternative method of warm-up, interest in semiocluded vocal tract exercises continues to grow. These exercises are thought to facilitate ease of phonation because the back pressures keep the vocal folds optimally separated. Semiocluded exercises have been compared with a primarily articulatory exercise, saying fast rhymes, performed by professional speakers.<sup>6</sup> Both warm-ups were performed relatively briefly before vocal tract observation with magnetic resonance imaging (MRI), as well as acoustic analysis. After warm-up, both speakers produced increased sound pressure level (SPL) and demonstrated a cluster of upper formants. MRI results differed between subjects who demonstrated laryngeal lowering, and wider pharyngeal area, respectively. In a second study of semiocluded vocal tract exercises, Duke et al<sup>7</sup> compared traditional warm-up such as *mesa di voce*, with phonation of the Star Spangled Banner through a 5-mm diameter straw for 6 minutes. The primary dependent variable was the singing power ratio (SPR), an indication of the relative amplitude of the high-versus low-frequency resonance peaks. The presence of a singer's formant would be indicated by a low SPR. Contrary to the proposed hypothesis, the investigators found no difference in SPR after traditional versus semiocluded warm-up in SPR. It is possible that aerodynamic, rather than acoustic, measures would have revealed differences, although the participants indicated no significant effect of either warm-up on perceived phonatory effort. The authors suggested that warm-up may induce physiological differences that are not detectable with current acoustic measures. It is also possible that, for some people, traditional vocal warm-ups may not be adequate to bring about the physiological changes associated with more general physical warm-up for an activity.

Because singing is a highly physical activity, it is reasonable to turn to exercise physiology literature when considering warm-up strategies. The most frequently cited effects of a physical warm-up are increased temperature and blood flow. The benefits of these two effects are extensive and include "faster muscle contraction and relaxation, greater economy of movement because of lowered viscous resistance within active muscles, improved oxygen delivery and use by muscles, facilitated nerve transmission and muscle metabolism, and increased blood flow through active tissues."<sup>8</sup> Exercise researchers have also considered the various combinations of warm-up strategies. For example, in a stretching protocol in preparation for swimming sprints, times only improved when stretching was combined with a sport-specific warm-up, rather than with a general aerobic warm-up.<sup>9</sup> Also investigating optimal warm-up strategies for swimming, other researchers highlighted the importance of individual differences in designing warm-ups and optimizing performance.<sup>10</sup> The most interesting protocol was explored by Murphy et al,<sup>11</sup> who varied the timing of aerobic activity combined with static stretching. They found that joint range of motion was optimized when stretching exercises were both preceded and followed with 5 minutes of running. Furthermore, they found that the beneficial effect lasted at least 30 minutes after the warm-up. They suggested that the second aerobic component following the static stretching may have maintained the

elevated temperature for a longer period of time than either running alone, or running only before stretching.

In an initial exploration of the potential impact of exercise on vocal warm-up, 20 actors performed either vocal warm-up in isolation, or vocal warm-up preceded by aerobic exercise.<sup>12</sup> The 20-minute vocal warm-up consisted of relaxation with soft, gentle phonation that gradually increased in both pitch and loudness. In a second condition, the actors performed aerobic exercise before the vocal warm-up. They completed exercises such as stepping, marching, jogging, and jumping jacks to maintain their calculated aerobic target heart rate for 5 minutes. Results of this study differed by gender. Women demonstrated a significant reduction in phonatory threshold pressure in the vocal plus aerobic warm-up condition. Men, on the other hand, demonstrated improvement in acoustic measures in the vocal warm-up only condition. The authors suggested two possible reasons for this finding. First, men and women may differ in vocal fold composition, particularly regarding hyaluronic acid, a water-binding molecule. Second, the finding may be attributed to a quirk of the sample, in that the men's responses to the NASA Physical Activity Questionnaire indicated they were in better physical condition.

The differential impact cited previously highlights the importance of tailoring the warm-up to the individual. Variables that may impact the construction of a warm-up may include a performer's vocal health and general health, as well as voice use and hydration on the day of performance. Furthermore, the demands and expectations of the performance must also be considered.<sup>4</sup>

It is clear that there are many variations on the theme of warming up to optimize performance. Although some benefit has been found for traditional vocal warm-up strategies, as well as semiocluded vocal tract exercises, and vocal exercises combined with aerobic exercise, warming up exclusively with an aerobic exercise has not been studied. The present study was designed to determine if a general, aerobic exercise would impact voice production in highly trained classical singers. It was hypothesized that after exercise, singers would increase SPL, prephonatory inspiration, estimated subglottal pressure, airflow, and vocal efficiency.

## METHODS

The study was approved by the Committee for the Protection of Human Subjects at the University of Houston. All participants signed an informed consent before beginning the study.

### Participants

Sixteen graduate and six undergraduate students in an academic vocal performance program were participated. There were 11 sopranos, one mezzo-soprano, five tenors, three baritones, and two bass/baritones. The participants reported no history of asthma or other respiratory problems, nor did they indicate any current respiratory condition such as a cold that might impact aerobic function. Age ranged from 19–38 years, with a mean of 24 (standard deviation, 4.4). All participants completed the Physical Activity Readiness Questionnaire

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